P. Swarajya LAKSHMI* & T. PULLAIAH*: **Reproductive biology of *Tithonia diversifolia* (Asteraceae)**

P.S. ラクシュミ*・T. プライア*: *Tithonia diversifolia* (キク科) の胚学的研究

Tithonia diversifolia (Hemsley) A. Gray belongs to the tribe Heliantheae of the family Asteraceae. Out of the ten species of the genus *Tithonia* the embryology of only one species *T. rotundifolia* was investigated (Pullaiah 1978) and hence the present investigation has been undertaken to study the embryology of *T. diversifolia*.

Material and methods The material was collected by Dr. T. Pullaiah from Coonoor in Nilgiris in Tamilnadu. Capitula of different sizes were fixed in F. A. A. They were dehydrated in tertiary butyl alcohol series and paraffin wax of melting point 58–60°C was used for embedding the material. Serial longitudinal and transverse sections of 5–10 μm thickness were stained in Delafield's haematoxylin. The voucher specimen no. TP 3098 has been deposited in Herbarium of Sri Krishnadevaraya University and Madras Herbarium (MH) Coimbatore.

Observations Microsporangium, microsporogenesis and male gametophyte. The anthers are tetrasporangiate (Fig. 1, A). Five archesporial cells which can be identified by their larger size and conspicuous nuclei are differentiated hypodermally in each lobe (Fig. 1, B). These cells divide periclinally giving rise to a primary sporogenous layer towards inside and a primary parietal layer towards outside (Fig. 1, C). The latter divides periclinally again to give rise to two layers of which the inner functions as the tapetum and the outer layer undergoes one more division periclinally forming a hypodermal layer and a middle layer (Fig. 1, D). Thus the wall development follows the Dicotyledonous type (Davis 1966).

The epidermis undergoes only anticlinal divisions to keep pace with the growing anther. Afterwards, these cells get elongated and flattened. The hypodermal cells by developing fibrous thickenings form endothecium (Fig. 1, E).

* Department of Botany, Sri Krishnadevaraya University, Anantapur 515 003, A. P., India.

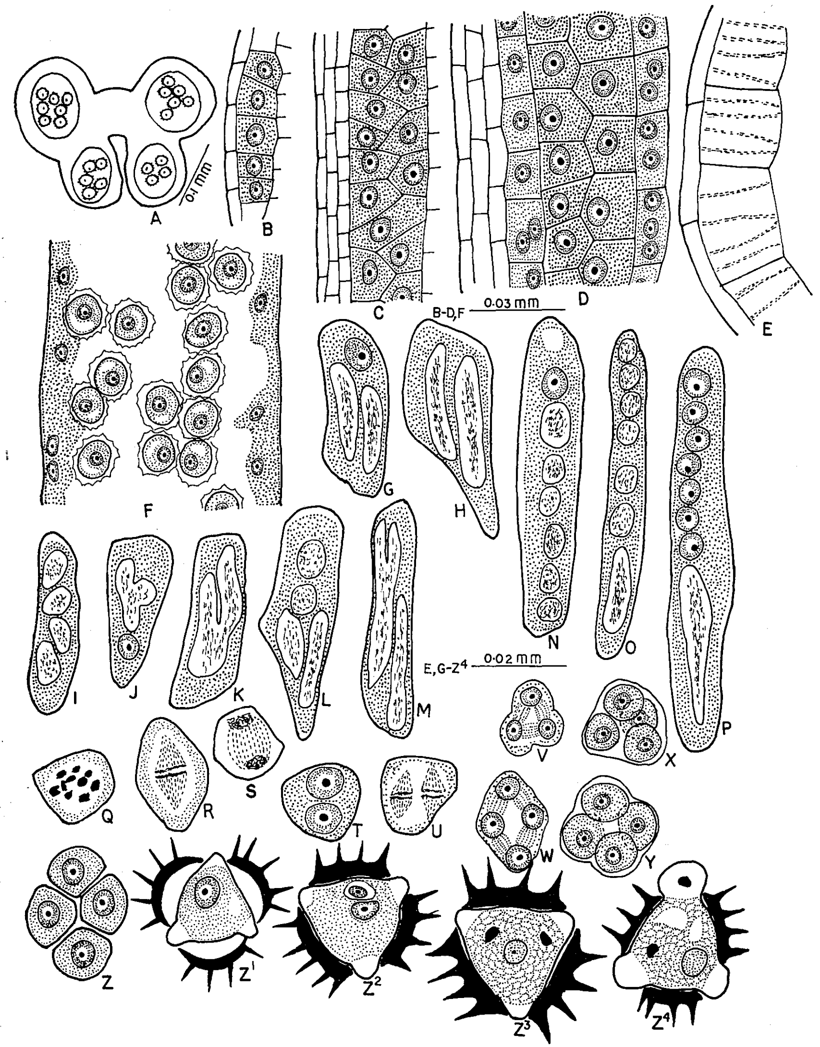

Fig. 1. *Tithonia diversifolia*. A. Transverse section of anther at one-nucleate pollen grain stage. B. Longitudinal section of part of anther lobe showing archesporium. C, D. Longitudinal sections of part of anther lobes showing wall development. E. Fibrous endothecium. F. Longitudinal section of part of anther lobe showing one-nucleate pollen grains and periplasmodium. G–P. Tapetal cells showing nuclear variations. Q–W. Meiotic divisions in the pollen mother cells. X. Tetrahedral pollen tetrad. Y, Z. Decussate pollen tetrad. Z^1, Z^2. One- and two-nucleate pollen grains respectively. Z^3, Z^4. Three-celled pollen grain.

At about the pollen tetrad stage, the middle layer gets crushed and degenerated.

The innermost layer of the anther wall is the tapetum. The nuclei of these cells undergo mitotic divisions and fusions resulting in multinucleate and polyploid cells (Fig. 1, G-P). The walls of the tapetal cells break down and the cytoplasm protrudes into the spaces between the pollen grain forming the periplasmodium (Fig. 1, F). Thus anther tapetum is of the Amoeboid type. It gets absorbed by the developing pollen grains.

The primary sporogenous cells undergo divisions giving rise to two rows of microspore mother cells (Fig. 1, D). These cells round off and produce tetrahedral and decussate pollen tetrads by undergoing meiosis (Fig. 1, Q-Z). Cytokinesis is by furrowing. The microspores after their separation from the tetrad, enlarge, become spherical and develop thick spinous exine (Fig. 1, Z^1). One-nucleate pollen grain divides and produces a large vegetative and a small generative cell (Fig. 1, Z^2). The latter, which gets pinched off into the pollen grain, divides and produces two spherical shaped sperms (Fig. 1, Z^3, Z^4). Mature pollen grains have thick exine and three germ pores.

Megasporangium, megasporogenesis and female gametophyte. Ovary is inferior, bicarpellary, syncarpous and unilocular with single basal ovule. During development the ovule curves and attains an anatropous condition (Fig. 2, B, C). Ovules are unitegmic and tenuinucellate.

At the time of megaspore tetrad formation, the inner layer of the integument becomes differentiated as endothelium and after fertilization, it becomes biseriate at the chalazal side (Fig. 4, C-E).

Nucellus consists of a single layer of epidermal cells surrounding single archesporial cell (Fig. 2, A). The archesporial cell enlarges considerably and functions directly as the megaspore mother cell. This cell later undergoes meiotic divisions and produces linear tetrad of megaspores (Fig. 2, D). Three micropylar megaspores degenerate whereas the chalazal one is functional (Fig. 2, E) which later develops into an 8-nucleate *Polygonum* type of embryo sac through mitotic divisions (Fig. 2, F-H). Synergids are hooked and the two polar nuclei lie near the egg apparatus. Initially antipodals are two or three in number. When there are two antipodals, the upper cell is binucleate (Fig. 2, H). They increase in number up to six by cell divisions. Due to nuclear divisions and fusions, the cells show many variations in their nuclear behaviour (Fig. 3, A-L) ; some cells are multinucleate while others have polyploid nuclei and both these

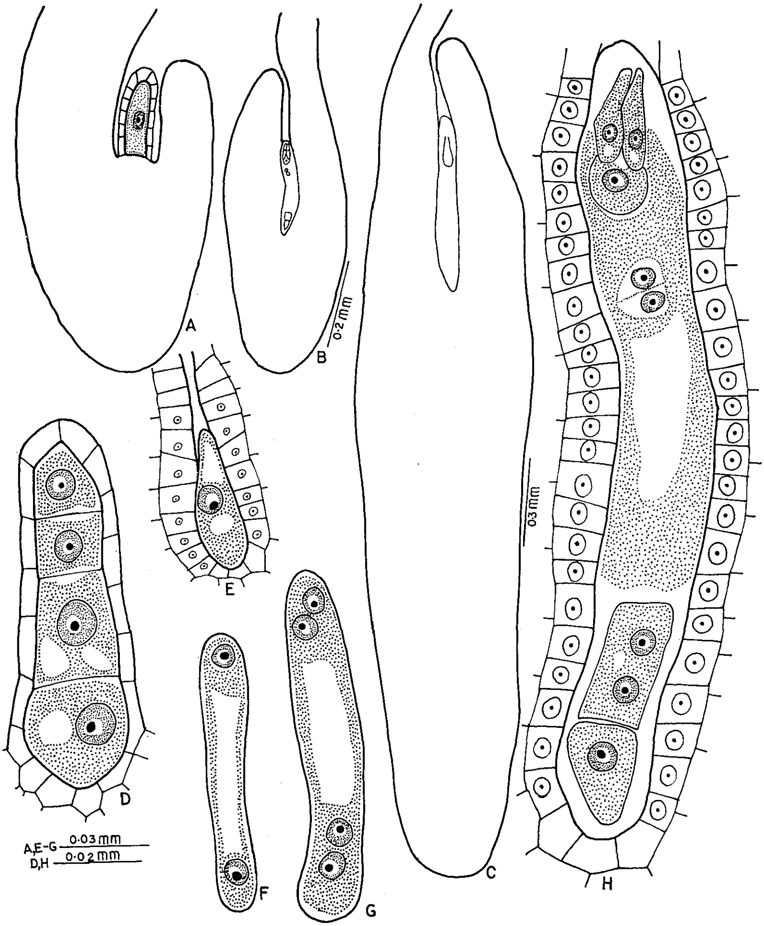

Fig. 2. *Tithonia diversifolia.* A–C. Development of ovule. D. Megaspore tetrad. E–G. One-, two- and four-nucleate embryo sacs respectively. H. Mature embryo sac.

conditions may be seen in still others.

Fertilisation, endosperm and embryo. Fertilisation is porogamous (Fig. 4, A). Syngamy and triple fusion occur simultaneously. Pollen tube persists up to 2-celled embryo stage. The primary endosperm nucleus undergoes free nuclear divisions and resulting nuclei are mostly distributed in the micropylar part of the embryo sac (Fig. 4, A). Wall formation starts at the micropylar side and

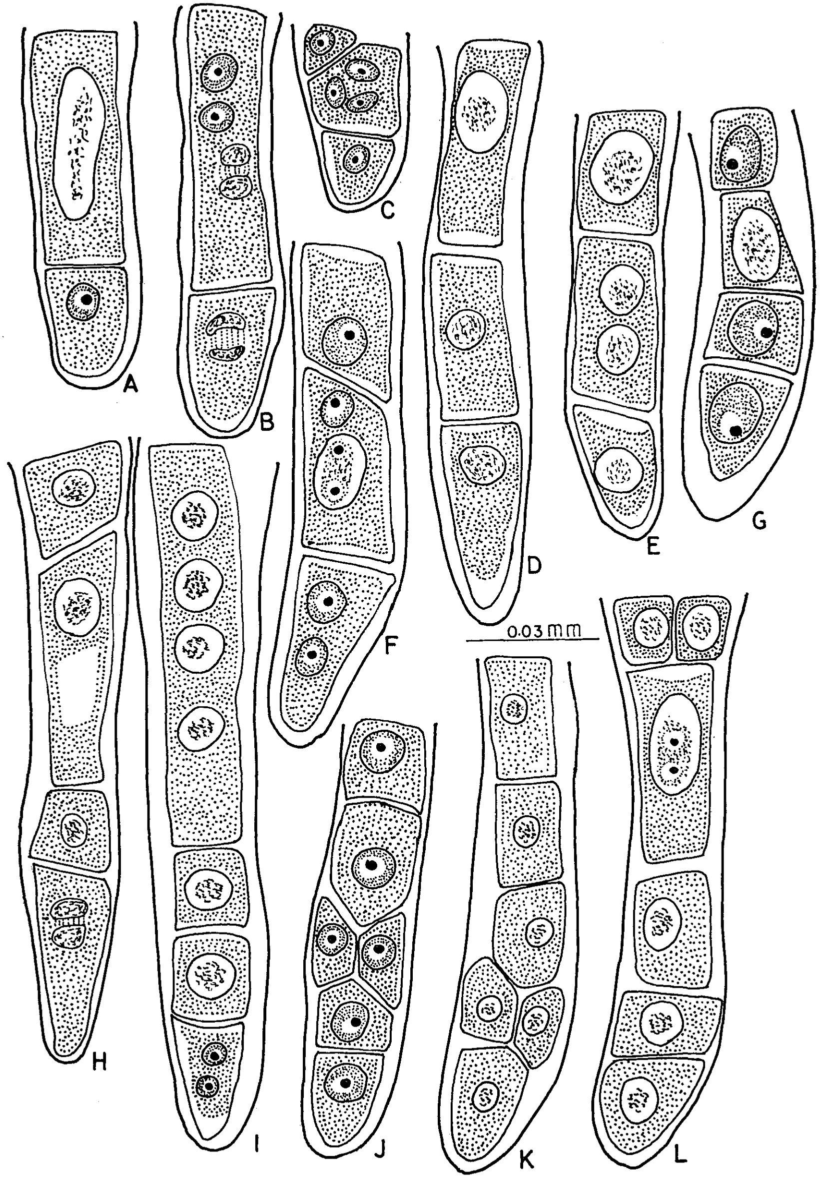

Fig. 3. *Tithonia diversifolia*. A-L. Antipodal cells.

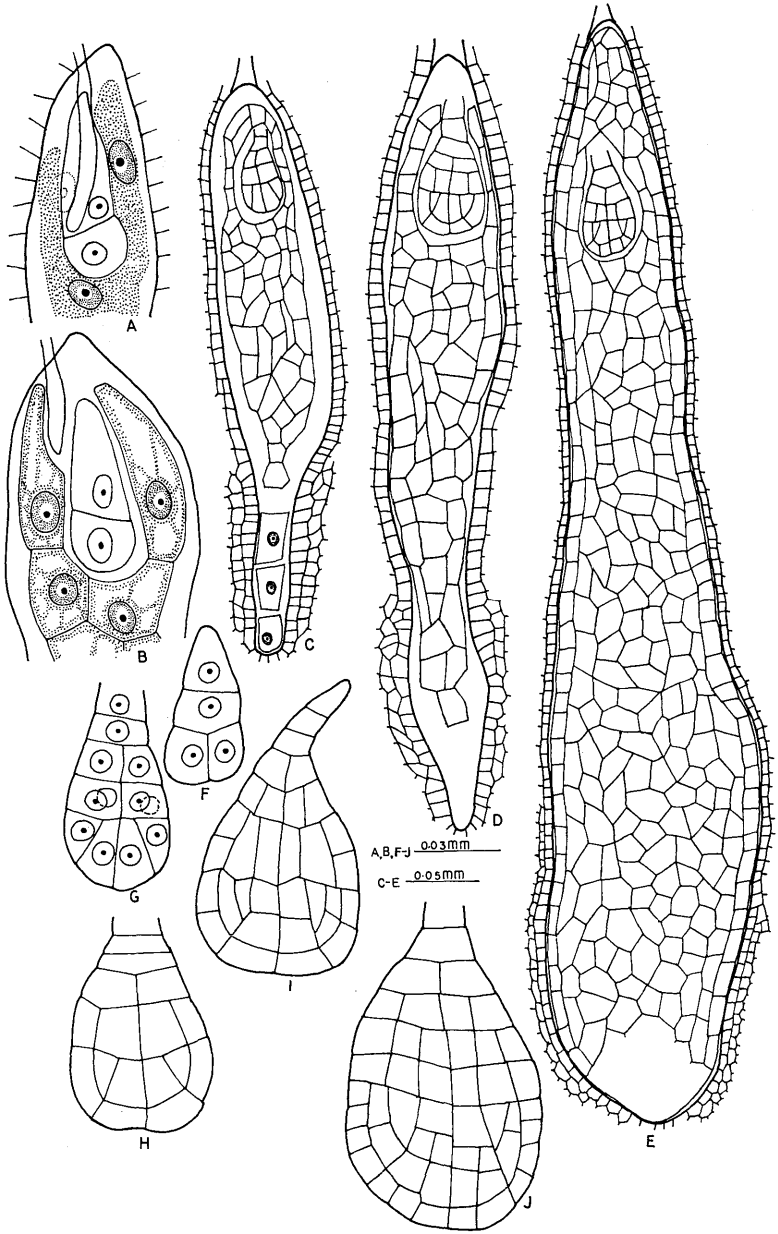

Fig. 4. *Tithonia diversifolia*. A–E. Stages in the development of endosperm. F–J. Stages in the development of embryo.

later filling the entire embryo sac (Fig. 4, B–E). Thus endosperm development is of the Nuclear type. The size of the embryo sac increases lengthwise and when the embryo reaches the globular stage, the peripheral cells of the endosperm become differentiated as the jacket layer (Fig. 4, E). Except this layer entire endosperm is consumed by the growing embryo.

The first division of the zygote is transverse resulting in a two-celled embryo, the terminal cell *ca* and the basal cell *cb* (Fig. 4, A). The cell *ca* divides vertically and the basal cell *cb* divides transversely to form a four-celled embryo (Fig. 4, F). Now the embryonal tetrad consists of juxtaposed cells derived from terminal cell and *m* and *ci* derived from the basal cell. The derivatives of the tier *ca* undergo one more vertical division and later oblique division resulting in octants. The cell *m* also undergoes two more vertical divisions at right angles to one another. The cell *ci* divides transversly resulting in the formation of *n* and *n'* which later give rise to cells *o* and *p* by transverse division (Fig. 4, G).

The derivatives of the tier *q* give rise to the cotyledons and stem tip, *m* to the hypocotyledonary region, *o* to the root cap and dermatogen of the root, *n* to the remaining part of the root tip and *p* to the suspensor of 2–6 cells (Fig. 4, H–J). Thus, embryogeny conforms to the *Senecio* variation of Asterad type.

Discussion The present taxon shows the charactersitic features of the family Asteraceae like Dicotyledonous type of anther wall development, periplasmodial anther tapetum, three-celled pollen grains, anatropous, unitegmic and tenuinucellate ovule, presence of endothelium and Asterad type of embryo development.

Harling (1962) and Eliasson (1971, 1972, 1974) stated that the formation of 2–3 secondarily multinucleate antipodals is characteristic of the tribe Heliantheae. But in *Tithonia rotundifolia*, *Acanthospermum hispidum* (Pullaiah 1978, 1981) and *Tithonia diversifolia* (present study) occurence of multinucleate and polyploid antipodals is noticed. Hence it may be said that the opinion of Harling (*op. cit.*) and Eliasson (*op. cit.*) is incorrect.

References

Davis, G. L. 1966. Systematic embryology of the Angiosperms. John Wiley and Sons, New York. Eliasson, U. 1971. Studies in Galapagos plants. X.

The genus *Lecocarpus*. Svensk bot. Tidskr. **65**: 246–277. —— 1972. Studies in Galapagos plants XI. Embryology of *Macraea laricifolia* (Compositae). Svensk bot. Tidskr. **66**: 43–47. —— 1974. Studies in Galapagos plants XIV. The genus *Scalesia*. Op. bot. **36**: 1–117. Harling, G. 1962. On some Compositae endemic to the Galapagos islands. Acta Hot. Berg. **20**: 63–120. Pullaiah, T. 1978. Embryology of *Tithonia*. Phytomorphology. **28**: 437–444. —— 1981. Embryology of *Acanthospermum hispidum*. Curr. Sci. **50**: 992–994.

* * * *

キク科 *Tithonia diversifolia* の花粉，胚嚢，胚乳，胚の初期発生を調べた。花粉の始原組織は5細胞からなる。花粉母細胞の形成は双子葉型である。花粉の四分子の形成は tetrahedral と decussate tetragonal の両者が見られた。タペタム形成はアメボイド型である。花粉は大きな栄養細胞と小さな精細胞からなる。胚珠は倒生で珠皮は1枚，薄層珠心である。胚嚢形成は普通型。反足細胞は6細胞にまでなる。胚乳形成は多核型である。胚形成は Asterad type の *Senecio* vairation である。

□Foster, M. S. & D. R. Schiel: **The ecology of giant kelp forests in California: a community profile** U. S. Fish Wildl. Serv. Biological Report 85 (7.2). 152 pp. 1985. 古く Darwin (1860) により紹介されて以来広くその名を知られた世界最長の海藻オオウキモ (*Macrocystis*) は，スキューバ潜水技術が発達する1950年代以前は不明の点が多かった。1954年の H. B. S. Womersley の分類の研究および1971年の W. J. North の編著によるオオウキモ海中林の生物学的研究が出るに至って，漸く全貌の一端がわかるようになった。本書は特にカリフォルニア沿岸のオオウキモを中心に，これまでの研究成果をレヴューしたもので，分類・分布，生育環境，オオウキモ海中林と生物の相互作用，海中林生態系，海中林の管理と環境汚染，リクリエーションの場としての海中林，要約などの7章から構成される。オオウキモは海洋沿岸帯の生態系における重要な生産者であり，またアルギン酸の原藻あるいはメタン発酵による熱エネルギーの原料として広く世の注目を浴びている。巨大海藻オオウキモに興味をもつ人や海中林一般に関心をもつ人には有難い出版物である。巻末にはオオウキモおよび関係をもつ生物の生態や分布等を扱った文献540が収録される。Information Transfer Specialist, National Coastal Ecosystems Team, U. S. Fish and Wildlife Service, National Wetlands Research Center, 1010 Gause Boulevard, Slidell, LA 70458, U. S. A. に申込めば本書の送付を受けることができる。 (千原光雄)